

SOCIO-ECONOMIC FOOTPRINT OF THE ENERGY TRANSITION

SOUTHEAST ASIA

2ND EDITION



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ABBREVIATIONS

ACE	ASEAN Centre for Energy
AEC	ASEAN Economic Community
AfDB	African Development Bank
APAEC	ASEAN Plan of Action for Energy Cooperation
ASEAN	Association of Southeast Asian Nations
CAGR	compound annual growth rate
CO₂	carbon dioxide
ETWI	Energy Transition Welfare Index
EU	European Union
EV	electric vehicle
FDI	foreign direct investment
GDP	gross domestic product
GHG	greenhouse gas
IRENA	International Renewable Energy Agency
Lao PDR	Lao People's Democratic Republic
LULUCF	land use, land-use change and forestry
PES	Planned Energy Scenario
PV	photovoltaic
UNIDO	United Nations Industrial Development Organization
US	United States
USD	United States dollar

EXECUTIVE SUMMARY

The transition of the Association of Southeast Asian Nations (ASEAN)¹ towards renewable energy is marked by strategic ambitions, shifting policies and complex geopolitics. As the world leans towards a greener future, member countries of ASEAN are amplifying their focus on renewable energy sources to reduce dependence on fossil fuels and fortify energy security. Their commitment to advancing the clean energy transition is underscored by comprehensive policy integration efforts. Through the ASEAN Plan of Action for Energy Cooperation and with the support of the ASEAN Centre for Energy, member states have agreed on regional initiatives such as the ASEAN Power Grid and ambitious renewable energy targets. As ASEAN prepares the next phase of the ASEAN Plan of Action for Energy Cooperation (2026-2030), it is reaffirming its commitment to an increasingly integrated, secure and sustainable energy transition that will define its energy landscape in the decades ahead.

The region is at a pivotal crossroads: shifting global power, the rapid energy transition and closer co-operation within the region are re-defining its strategic course. As one of the world's most dynamic and diverse regions, ASEAN needs to balance the imperatives of geo-economics, a just and secure energy transition, and enhanced regional integration (including through power inter-connection). These interlinked dimensions not only define the present challenges the region faces, but also are key to unlocking a more resilient, inclusive and sustainable future.

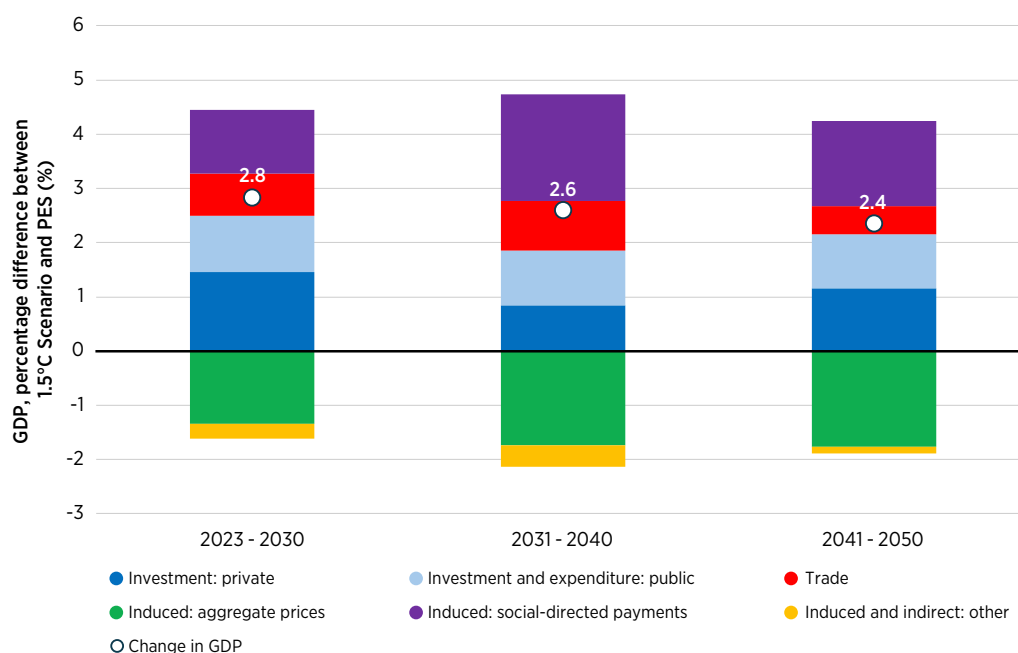
Since COVID-19, the ASEAN energy landscape has seen notable shifts. Economic recovery has driven energy demand, which has been addressed while keeping sustainability in focus. The pandemic highlighted energy security vulnerabilities, prompting enhanced measures towards a more sustainable, more resilient energy future for the region. This is all happening alongside the wider geopolitical changes in the world. At the 42nd ASEAN Meeting of Energy Ministers in September 2024, the International Renewable Energy Agency (IRENA) elevated the importance of interconnection benefits to the ministerial level, reflecting an update of the ASEAN renewable outlook (IRENA and ACE, 2022). The present document is an updated brief evaluating the socio-economic impact of that updated ASEAN outlook. As such, it provides insights into how a comprehensive energy transition could affect the region's economies and people.

Under the 1.5°C Scenario, ASEAN's gross domestic product (GDP) in 2023-2050 is expected to increase by a yearly average of 2.6% beyond the growth already anticipated in the Planned Energy Scenario (PES). The new estimates in the updated outlook indicate a more stable and evenly distributed gain across all three decades of the transition (Figure S1). This would translate to an estimated difference of roughly USD 4.8 trillion² in average cumulative GDP between the 1.5°C Scenario and the PES from 2023 to 2050. Transition-related investments (in energy efficiency and other end uses, grids and energy flexibility, and mainly renewables), along with an improved trade position, would play a key role in this GDP difference, offsetting declining investments in and imports of fossil fuels.

¹ The ASEAN member states are Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. Timor-Leste at the time of drafting this report (May 2025) was not a member, they officially joined ASEAN on 26 October 2025. The terms "ASEAN" and "Southeast Asia" are used interchangeably to refer to this group of countries unless otherwise mentioned.

² In 2021 USD.

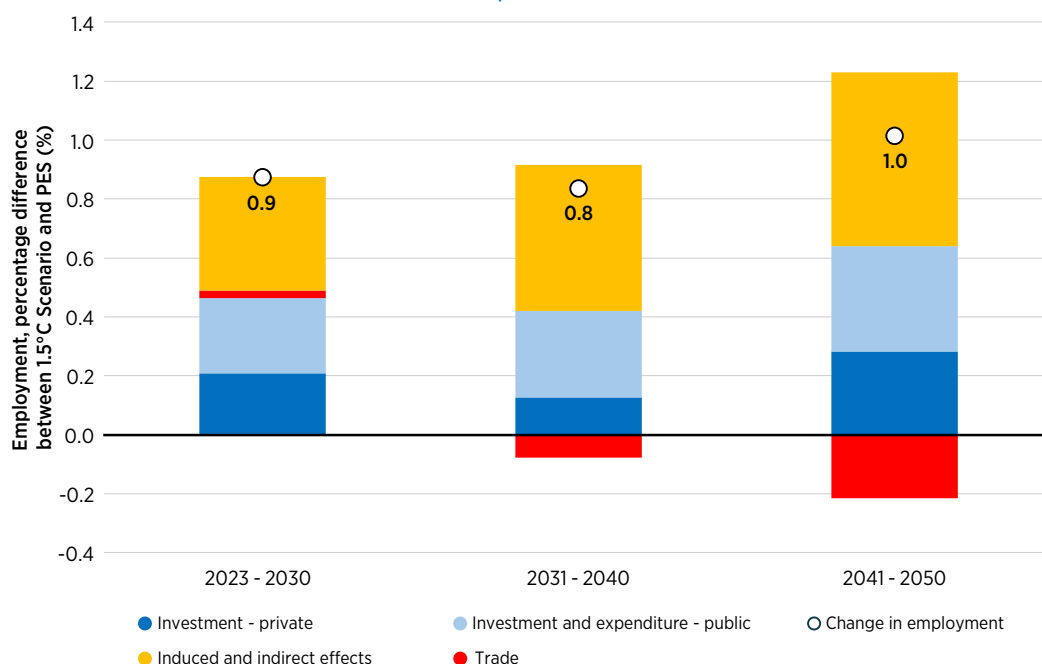
Figure S1 GDP in ASEAN region: Percentage differences between the 1.5°C Scenario and the PES, by driver, 2023-2050



Notes: ASEAN = Association of Southeast Asian Nations; GDP = gross domestic product; PES = Planned Energy Scenario.

Economy-wide employment is expected to be consistently higher (by a yearly average of 0.9%) in the 1.5°C Scenario than the PES between 2023 and 2050 (Figure S2). This would translate to over 3.3 million additional jobs in 2050. This updated assessment also demonstrates a more equitable distribution of economy-wide employment gains across the transition period, underpinned by a more evenly spread contribution from key macroeconomic drivers, particularly investment, and induced and indirect effects, while trade has a minor impact.

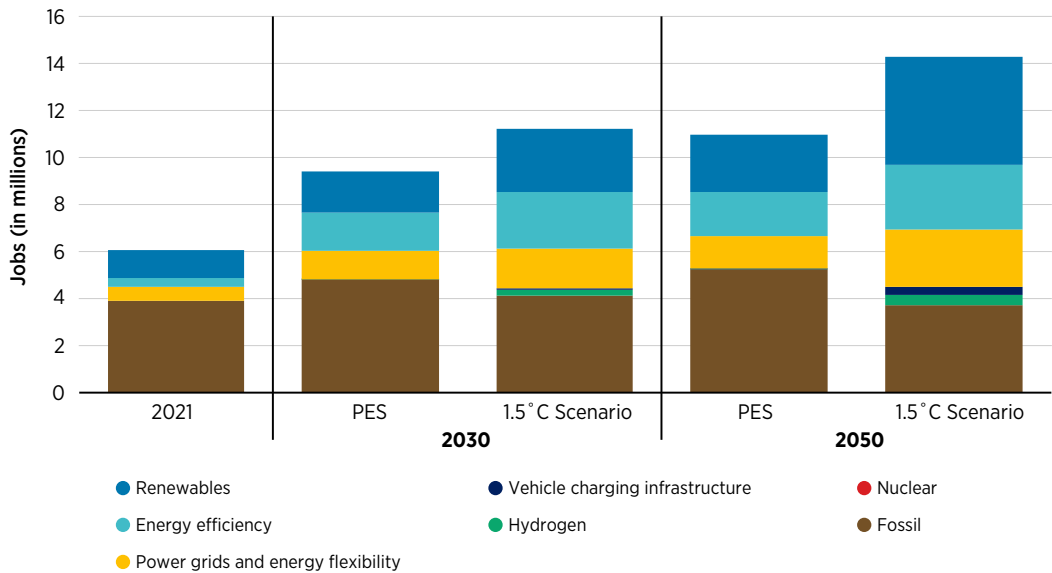
Figure S2 Economy-wide employment in ASEAN, percentage differences between the 1.5°C Scenario and the PES, by driver, 2023-2050



Notes: ASEAN = Association of Southeast Asian Nations; PES = Planned Energy Scenario.

The energy sector is expected to have roughly 14.3 million jobs in 2050 under the 1.5°C Scenario. This is well above the 11 million jobs under the PES and close to 2.5 times the jobs in 2021 (around 6.1 million jobs) (Figure S3). Employment in fossil fuels would remain substantial (at around 4.1 million jobs) up to 2030 but gradually contract (to 3.7 million) by 2050 under the 1.5°C Scenario. However, jobs in renewables, energy efficiency, grids and emerging sectors such as hydrogen and electric mobility would expand significantly. The structure of this report is as follows:

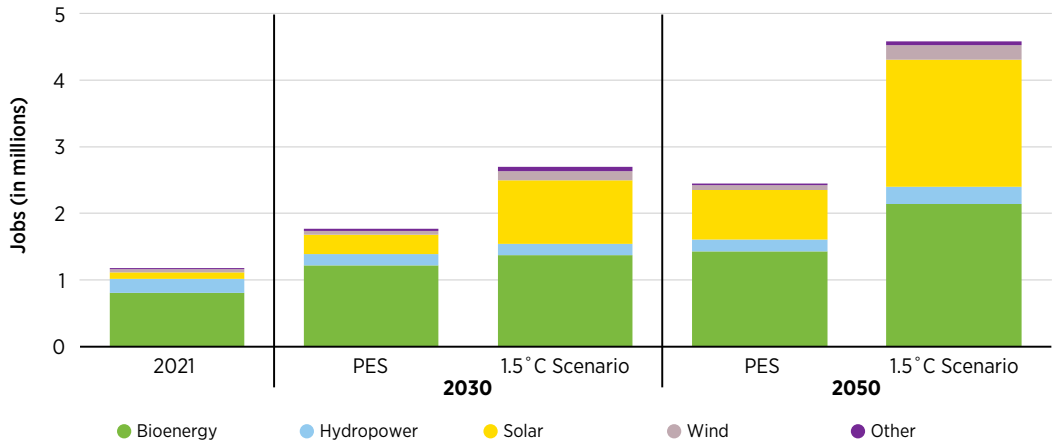
Figure S3 Overview of energy sector jobs in ASEAN under the PES and the 1.5°C Scenario, by sector, 2021-2050



Notes: ASEAN = Association of Southeast Asian Nations; PES = Planned Energy Scenario.

The growth in renewable energy jobs is substantial in the 1.5°C Scenario, reaching about 4.6 million by 2050. This is almost double the new renewable energy jobs expected in the PES and almost four times the 1.2 million jobs in 2021 (Figure S4). This growth results from increased use of all types of renewables and a ramp-up of local manufacturing, installation and maintenance. Indonesia leads ASEAN in total renewable energy employment in 2050 under the 1.5°C Scenario, accounting for 43% of the region’s renewable energy jobs. Malaysia contributes 9%, while the remaining eight ASEAN countries together contribute 48%. Bioenergy jobs dominate, at more than 2.1 million, followed by solar at 1.9 million. Wind, hydro and emerging renewables together add nearly 530 000 jobs.

Figure S4 Overview of renewable energy jobs in ASEAN under the PES and the 1.5°C Scenario, 2021-2050



Notes: ASEAN = Association of Southeast Asian Nations; PES = Planned Energy Scenario.

The energy transition's societal impacts are important to evaluate. Considering key aspects of societal well-being, IRENA has developed and refined its Energy Transition Welfare Index (ETWI) for an extended impact analysis. The methodological framework of the IRENA ETWI allows a direct comparison between scenarios, identifying potential opportunities and challenges for policy makers. The framework defines ten indicators, across five dimensions (Economic, Social, Environmental, Distributional and Access) to illustrate how targeted policies can improve socio-economic outcomes. ASEAN's ETWI score would improve through the transition period under the 1.5°C Scenario, reflecting better quality of life driven by early renewables deployment, electrification, energy efficiency, and greater investment in infrastructure and social spending. However, the social and distributional dimensions still see only modest contributions, which indicates that structural challenges remain embedded, and that targeted policies to tackle inequality and social protection are required.

To maximise socio-economic benefits, ASEAN would therefore need to harmonise regional policies, develop just transition strategies, improve grid inter-connection, develop critical minerals and launch targeted upskilling initiatives, while carefully balancing geopolitical influences from external actors and ensuring equitable and resilient development across all member states.

CHAPTER 1

ASEAN'S TRIPLE CHALLENGE: NAVIGATING GEO-ECONOMICS, REGIONAL INTEGRATION AND THE ENERGY TRANSITION

The Association of Southeast Asian Nations (ASEAN)³ is at a pivotal crossroads: shifting global power, the rapid energy transition and closer regional co-operation are redefining its strategic direction. The rapidly growing region, one of the world's most dynamic and diverse, has a strong economic presence on the global stage. Meanwhile, it needs to ensure a just and secure energy transition and improve regional integration through enhanced power inter-connection while giving geo-economics full consideration. These are inter-linked dimensions that not only define ASEAN's present challenges, but also are key to accelerating the transition towards a more resilient, inclusive and sustainable future.

The first part of the triple challenge, geo-economics, reflects the increased entanglement of economics and geopolitics in a multi-polar world. ASEAN's central position in the Indo-Pacific has made it an arena of competition among the major powers looking to exert their influence through trade, infrastructure and investment. As global competition deepens, the region will need to navigate these external pressures with prudence and assert its strategic independence in the process. This requires not only diplomatic nimbleness but also structural transformations to diversify partnerships and strengthen internal cohesion.

Addressing the second challenge, regional integration through power inter-connection, is becoming crucial for energy security and political co-operation. Initiatives such as the ASEAN Power Grid and efforts towards greater cross-border energy trade seek to optimise the allocation of resources, bolster the resilience of the inter-connection system and realise the region-wide sharing of benefits. As ASEAN economies are increasingly inter-linked, deeper infrastructure and policy integration will be critical, to realise the full potential of the energy transition and avoid geopolitical fragmentation.

The third challenge, accelerating the energy transition, is a strategic imperative. ASEAN's energy sector holds significant macroeconomic importance as it supports economic activities, strengthens energy security and promotes sustainable development. Amid rising global energy demand, elevated climate risks and a deepening commitment to decarbonisation, ASEAN's energy landscape is evolving, with profound implications – although at a varying rate across member countries. The shift from fossil fuels to renewables brings the promise of energy security, economic diversification and environmental sustainability. But it also exposes the region to fresh vulnerabilities, ranging from supply chain dependencies to the geopolitics of critical materials. The connections between macroeconomic factors and the energy sector have grown stronger, with implications for policy decisions, investment strategies and regional co-operation efforts.

ASEAN's journey towards renewable energy is marked by strategic ambitions, shifting policies and complex geopolitics. As the world leans towards a greener future, ASEAN countries are amplifying their focus on renewables, both as alternatives to fossil fuels and to fortify energy security. ASEAN's total greenhouse gas (GHG) emissions in 2019 were almost 25% greater than the EU27's and constituted 7.8% of global

³ The ASEAN member states are Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. Timor-Leste at the time of drafting this report (May 2025) was not a member, they officially joined ASEAN on 26 October 2025. The terms "ASEAN" and "Southeast Asia" are used interchangeably to refer to this group of countries unless otherwise mentioned.

GHG emissions. Indonesia leads regional emissions, and ranks fifth in the world, owing to its forests and carbon-rich peatlands (IRENA, 2023a). The land use, land-use change and forestry (LULUCF) sector is the greatest emitter,⁴ representing more than half of global LULUCF emissions (WRI, 2022).

Energy is central to achieving the ASEAN Economic Community's (AEC's) vision of a well-connected, integrated, competitive and resilient region. Since the AEC's establishment in 2015, primary energy has continued to rise significantly in the region, and is expected to more than double between 2017 and 2040 (ACE, 2021). The latest outlook published by the ASEAN Centre for Energy (ACE, 2024) forecasts an almost three-fold increase by 2050. All ASEAN member states have aligned their commitments through the ASEAN Plan of Action for Energy Cooperation (APAEC). ACE, meanwhile, is facilitating regional collaboration, aligned with the ASEAN Community Vision 2045. APAEC 2016-2025 laid the groundwork for a co-ordinated regional response. Encompassing a broad range of initiatives, from advancing the ASEAN Power Grid to setting ambitious renewable energy targets, APAEC reflected a collective drive to not only enhance energy security but also position ASEAN as a key player in the global energy transition. As ASEAN countries navigate these priorities, their strategies will shape the contours of the region's energy landscape for years to come. The year 2025 marks an important point in the region's energy trajectory: as APAEC 2026-2030 takes shape, it reaffirms the region's commitment to an ambitious and integrated energy transformation (ACE, 2025).

The International Renewable Energy Agency (IRENA) launched the report *Socio-economic Footprint of the Energy Transition: Southeast Asia* (IRENA, 2023a), which draws on the results of the 2021 edition of an annual flagship report, the *World Energy Transitions Outlook: 1.5°C Scenario Pathway* (IRENA, 2021a). The 2023 report explored the potential socio-economic impacts of the energy transition in Southeast Asia under two scenarios: a scenario based on current plans (the Planned Energy Scenario, PES),⁵ and an ambitious energy transition scenario (1.5°C Scenario)⁶ that seeks to limit the global rise in temperature to 1.5°C, consistent with the Paris Agreement. The analysis found that a comprehensive and increasingly ambitious energy transition will lead to improved socio-economic outcomes. Annual average GDP growth in Southeast Asia could be 3.4% higher under IRENA's 1.5°C Scenario than the PES between 2021 and 2050. Employment in energy would reach 11 million under the 1.5°C Scenario by 2050, of which renewable energy jobs would constitute roughly 45.8% (i.e. around 5.1 million jobs).

Later in 2022, IRENA also launched the 2nd edition of the Renewable Energy Outlook for ASEAN: Towards a Regional Energy Transition (IRENA *et al.*, 2022) in collaboration with ACE and the ASEAN Renewable Energy Sub-Sector Network. The report details comprehensive pathways for the development of a sustainable and cleaner regional energy system, exploring the role of end-use sector electrification; expansion of renewable generation; energy efficiency solutions; and emerging technologies such as electric vehicles, hydrogen and battery storage-systems, as well as the importance of expanding regional power sector integration. According to the report, ASEAN's energy-related carbon dioxide (CO₂) emissions rise to 2.1 gigatonnes (Gt) and 2.8 Gt in 2030 and 2050, respectively, under the PES (Figure 1). The power sector would be the largest emitter, followed by transport and industry. Together, these sectors constitute over 90% of the region's energy-related CO₂ emissions. The 1.5°C Scenario sees a decline in ASEAN's emissions of around 15% by 2030 and 75% by 2050 compared with the PES, after which emissions are fully curbed (Figure 1). Total installed renewable energy capacity increases substantially, from 27% in 2018 to 77% by 2050, under the PES. Variable renewable

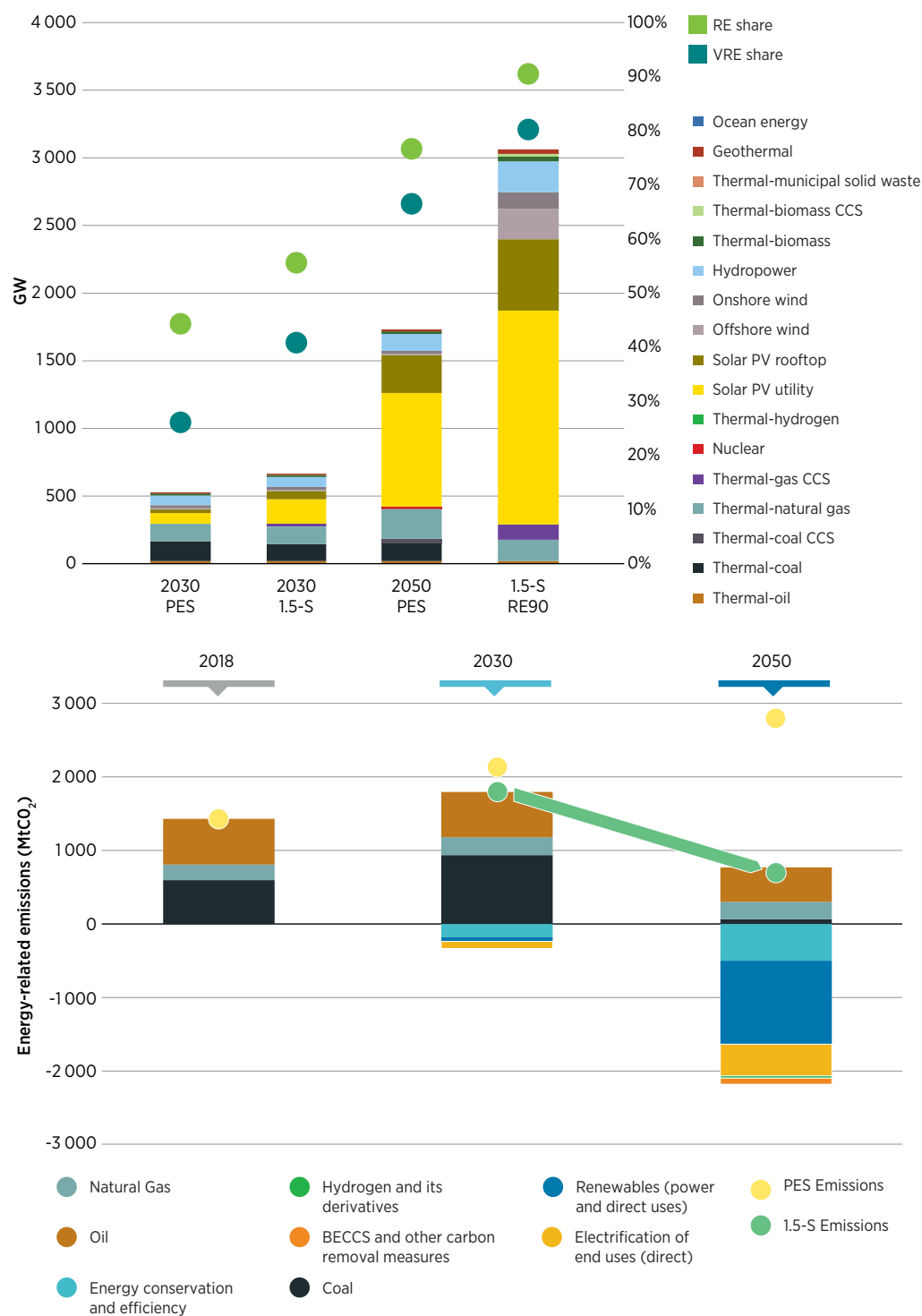
⁴ It reached emissions of 1 gigatonne of carbon dioxide equivalent in 2019 (WRI, 2022).

⁵ The PES is the reference case for this study, providing a perspective on energy system developments based on governments' energy plans, as well as other targets and policies planned before 2020, including Nationally Determined Contributions under the Paris Agreement. Policy changes and targets announced since 2020 are not considered in the modelling exercise but are mentioned to provide insights on the latest developments.

⁶ The 1.5°C Scenario describes an energy transition pathway in which the increase in global average temperature by the end of the present century is limited to 1.5°C, relative to pre industrial levels. The 1.5°C Scenario prioritises readily available technology solutions, including all sources of renewable energy, electrification measures and energy efficiency, that can be scaled up at the needed pace to reach the 1.5°C goal.

energy (mostly solar photovoltaic [PV]) constitutes nearly three-quarters of this capacity. Under the 1.5°C Scenario, installed renewable energy capacity exceeds 80% of all installed capacity by 2050; total renewable generation surpasses 90%. This allows for some remaining fossil fuel generators (mostly based on natural gas).

Figure 1 Evolution of energy-related CO₂ emissions in Southeast Asia, by technology type, under the 1.5°C Scenario, 2018, 2030 and 2050 (bottom) and installed power capacity under the PES and the 1.5°C Scenario, 2030 and 2050 (top)



Source: (IRENA *et al.*, 2022).

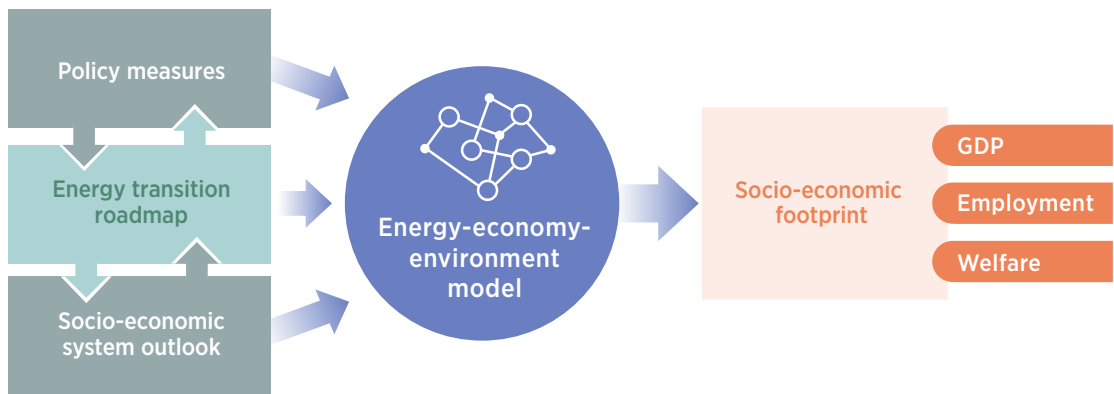
Notes: 1.5-S = 1.5°C Scenario; 1.5-S RE90 = 1.5°C Scenario with 90% renewable power generation; CCS = carbon capture and storage; GW = gigawatt; MtCO₂ = million tonnes carbon dioxide; PES = Planned Energy Scenario; PV = photovoltaic; RE = renewable energy; VRE = variable renewable energy.

Through to 2030, several energy transition technologies will see significant investment. Solar PV is a good example, as it will be key to the region’s short-term energy transition. The additional 240 gigawatts (GW) of installed solar PV capacity needed for the energy transition will require investment of roughly USD 160 billion. Investment related to electric vehicle (EV) development will also play an important role in the transition. Electric chargers are a necessity; nearly 4 million units will have to be installed by 2030, requiring nearly USD 50 billion. Investments in enabling infrastructure will also be crucial. International and domestic transmission will need around USD 105 billion, and local distribution another USD 69 billion. In the long term, through to 2050, investment in fossil fuel plants (including carbon capture and storage) decrease by one-third under the 1.5°C Scenario. The 1.5°C Scenario sees an average annual investment of USD 210 billion up to 2050; this is more than 2.5 times the investment required in the PES over the same time horizon.

Since COVID-19, the ASEAN energy landscape has seen notable shifts. Economic recovery has driven energy demand, which has been managed while giving priority to sustainability. The pandemic revealed gaps in energy security, prompting enhanced measures seeking a more sustainable and more resilient energy future for the region. This is all happening amid wider geopolitical changes at the global scale. At the 42nd ASEAN Meeting of Energy Ministers in September 2024, IRENA elevated the importance of inter-connection benefits to the ministerial level, reflecting an update to the ASEAN renewables outlook. This present document, an updated brief, assesses the socio-economic impact of that updated outlook and provides insights into how a comprehensive energy transition could affect the region’s economies and people.

Through its analysis of key drivers and impacts, IRENA has offered insights that support energy transition planning and implementation at the global, regional, and national levels since 2016 (IRENA, 2016, 2018, 2019a, 2019b, 2020, 2021b, 2021b, 2022a, 2023b, 2023c, 2023d). For the energy transition to be effective and broadly beneficial, IRENA has stressed the importance of a holistic socio-economic assessment framework that extends beyond the technology focus of traditional roadmaps (Figure 2). The framework proposed encompasses key policy aspects, spanning diverse technological, social and economic challenges, that mutually complement and support one another to hasten the transition and ensure its advantages are widely shared and difficulties minimised.

Figure 2 Socio-economic assessment framework



Note: GDP = gross domestic product.

The socio-economic analysis conducted for this brief used a macro-econometric model (Energy-Environment-Economy Global Macroeconomic, E3ME)⁷ that integrates the energy system and global economies into a single quantitative framework. The model sheds light on the trade-offs between economic prosperity and employment, while examining welfare aspects, including the distributional implications of policy choices.

⁷ The E3ME global macro econometric model (www.e3me.com) is used for assessing socio economic impacts. Energy mixes and the related investments, based on the World energy transitions outlook (IRENA, 2023d) and informed by the 2nd edition of the Renewable energy outlook for ASEAN (IRENA and ACE, 2022), are used as exogenous inputs for each scenario, as well as climate- and transition-related policies.

Policy makers need to be aware of how such choices will affect people's well-being and overall welfare, and of the potential gaps and hurdles that could affect progress. This brief provides valuable insights and recommendations for Southeast Asia's policy makers as they work to achieve a just and equitable low-carbon regional transition that creates jobs and reduces inequalities.

Importantly, the brief updates the socio-economic differences between the PES and the 1.5°C Scenario in Southeast Asia, taking into account the importance of regional inter-connection. It uses the same inputs and assumptions as the 2023 edition of the *World Energy Transitions Outlook* (IRENA, 2023d), which is informed by the 2nd edition of the *Renewable Energy Outlook for ASEAN* (IRENA *et al.*, 2022). Under the PES, ASEAN's economy is expected to maintain strong growth. Between 2023 and 2050, regional real GDP is projected to increase at a compound annual growth rate (CAGR) of around 4.7%; economy-wide employment is expected to increase at a CAGR of around 0.2%; and the region's population is projected to grow at a CAGR of 0.5%, reaching over 787 million in 2050 (Table 1).

Table 1 GDP, labour force and population growth projections under the PES (CAGR %)

VARIABLE	2023-2030	2031-2040	2041-2050
Real GDP	4.6	4.9	4.5
Economy-wide employment	0.4	0.2	0.0
Total population	0.8	0.5	0.3

Notes: CAGR = compound annual growth rate; GDP = gross domestic product; PES = Planned Energy Scenario.

As in previous regional analyses, IRENA's analysis continues to explore the socio-economic impacts of various assumptions included in the climate policy basket. These encompass a range of measures to support a just and inclusive transition – carbon pricing, international collaboration, subsidies, progressive fiscal regimes to address distributional aspects, investments in public infrastructure and spending on social initiatives. They also include policies that encourage the deployment, integration and promotion of energy transition technologies.

The next chapter presents the key findings of IRENA's socio-economic analysis for ASEAN until 2050. It outlines potential impacts on economic growth (GDP), employment and welfare, and considers underlying drivers. The findings delineate the differences between the 1.5°C Scenario and the PES.

CHAPTER 2

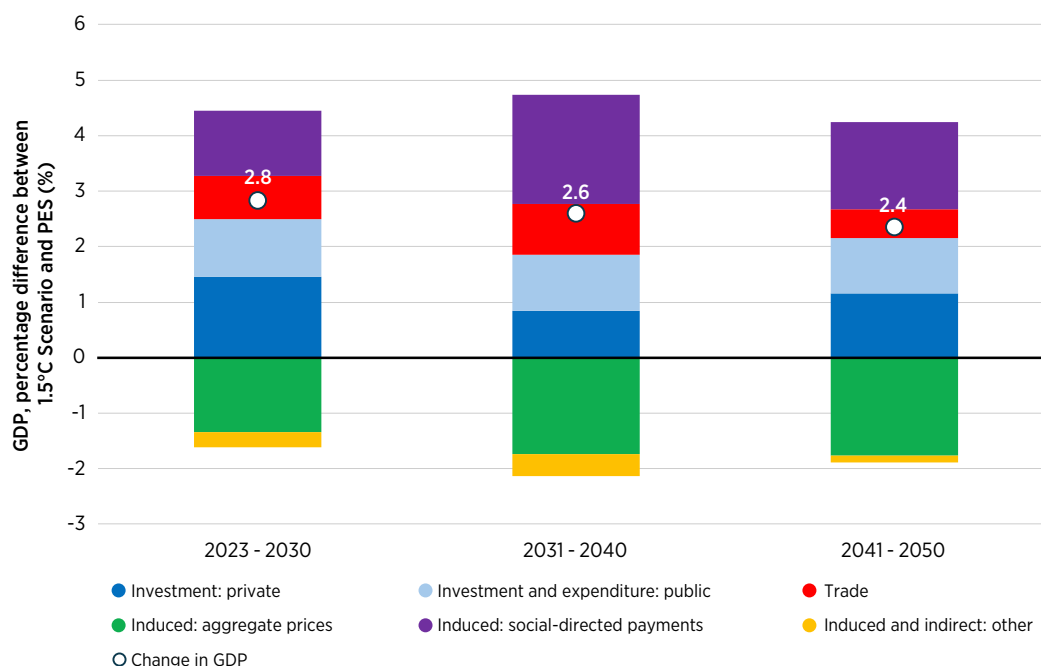
SOCIO-ECONOMIC IMPACTS OF THE ENERGY TRANSITION

2.1 ECONOMIC IMPACTS, AS MEASURED BY GDP

The 1.5°C Scenario would generate steady and substantial socio-economic benefits for the ASEAN region relative to the PES. A GDP difference is observed between the scenarios throughout the transition period, due to investment, trade and social policy interventions supported by regional integration efforts.

Under the 1.5°C Scenario, ASEAN's GDP would rise by a yearly average of 2.6% between 2023 and 2050 against the growth already anticipated under the PES; this highlights economic benefits from the transition. The new estimates in this updated brief indicate a more stable and evenly distributed regional gain across all three decades of the transition (see Annex 1 for a detailed comparison of the previous edition and this updated version). GDP is estimated to be 2.8%, 2.6% and 2.4% higher on yearly average terms under the 1.5°C Scenario than under the PES for the first decade (2024-2030), second decade (2031-2040) and third decade (2041-2050), respectively (Figure 3). Over 2023-2050, the region's economy is estimated to record an average cumulative GDP gain of around USD 4.8 trillion between the 1.5°C scenario and the PES; GDP will reach around USD 12.0 trillion by 2050 under the 1.5°C Scenario.⁸

Figure 3 GDP in ASEAN region: Percentage differences between the 1.5°C Scenario and the PES, by driver, 2023-2050



Notes: ASEAN = Association of Southeast Asian Nations; GDP = gross domestic product; PES = Planned Energy Scenario.

This shift towards balanced long-term effects from a pattern of more front-loaded growth is enabled by the inclusion of regional power inter-connection, and additional social-directed spending, which makes the transition more resilient and inclusive. It also mirrors a maturing policy environment across the ASEAN region, with increasing focus on sustaining the economic momentum beyond the initial wave of transition-related investments.

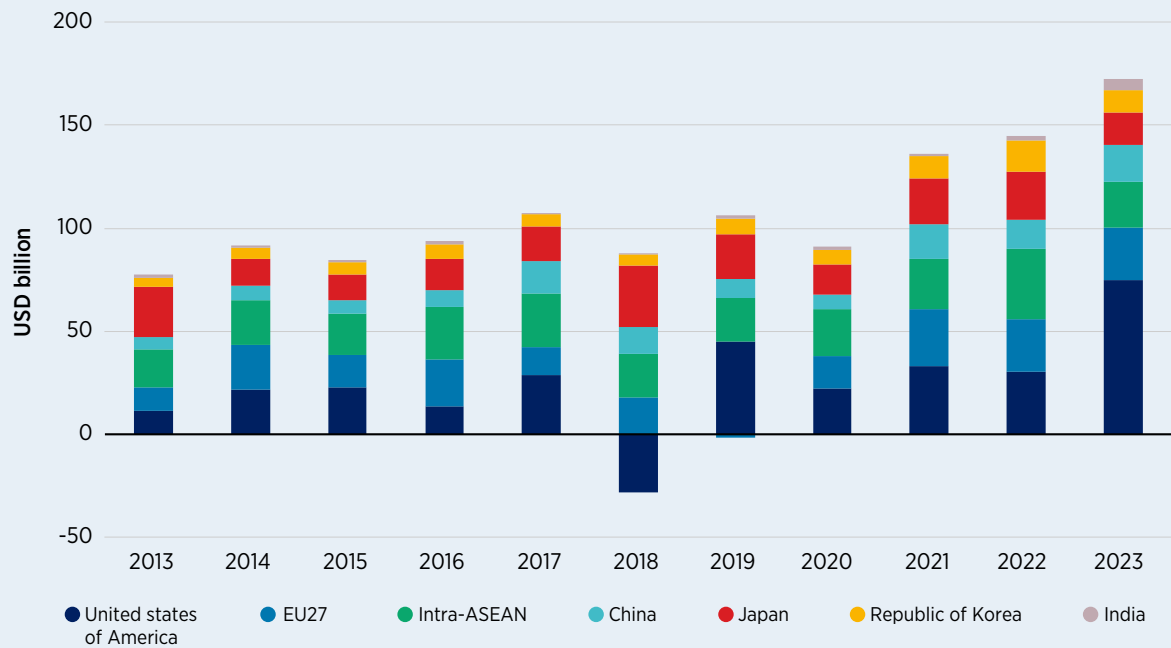
⁸ Both monetary figures are in 2021 USD.

To help understand the fundamental structural elements behind these trends, IRENA’s macroeconomic analysis disaggregates the GDP difference by drivers over the transition period. Investment and trade are still the main drivers, while indirect and induced effects have a much smaller role (Figure 3). **Private investment** emerges as a key driver of the GDP difference, with a positive impact throughout the transition. Cumulative private investment remains robust, increasing from USD 457 billion in the first decade to over USD 1.1 trillion by 2050. Foreign direct investment (FDI) could also play a catalytic role in not only supplementing domestic capital but also facilitating access to advanced technologies and wider supply chains (Box 1). Although declining fossil fuel investment in the power sector and reduced capital flows to fossil fuel supply exert downward pressure, this is more than offset by strong growth in private transition-related investments (energy efficiency and other end uses, grids and energy flexibility, and mainly renewables). But the reallocation of capital to the power sector can simultaneously crowd out investments in other sectors, such as construction, resulting in mixed sectoral outcomes.

Box 1 Foreign direct investment in ASEAN

The supply chain disruptions triggered by geopolitical tensions and COVID-19 in the early 2020s have benefited Association of Southeast Asian Nations (ASEAN) countries. They saw a crucial inflow of supply-chain-related foreign direct investment (FDI), which helped existing investors expand their capacities and new investors establish a presence in the region. Overall, ASEAN is among the leading recipients of investment among developing countries. FDI into the region grew remarkably between 2013 and 2023, from roughly USD 120.5 billion to over USD 234 billion; six ASEAN member states (Cambodia, Indonesia, Lao PDR, Philippines, Singapore and Viet Nam) saw FDI inflows increase over this period (ASEAN Stats, n.d.). In 2023, seven countries/regions led FDI into ASEAN: the United States (USD 75 billion, or 32% of the total FDI), EU27 (USD 25.4 billion, or 10.9%), intra-ASEAN (9.6%), China (7.5%), Japan (6.9%), the Republic of Korea (4.6%) and India (2.4%). Their combined contribution was almost three-quarters of the overall FDI flows into the region (approximately USD 173 billion) (Figure 4). Singapore maintained its position as the top FDI destination in the region, receiving about USD 159.6 billion in 2023, followed by Indonesia and Viet Nam, at around USD 22 billion and USD 18.5 billion, respectively.

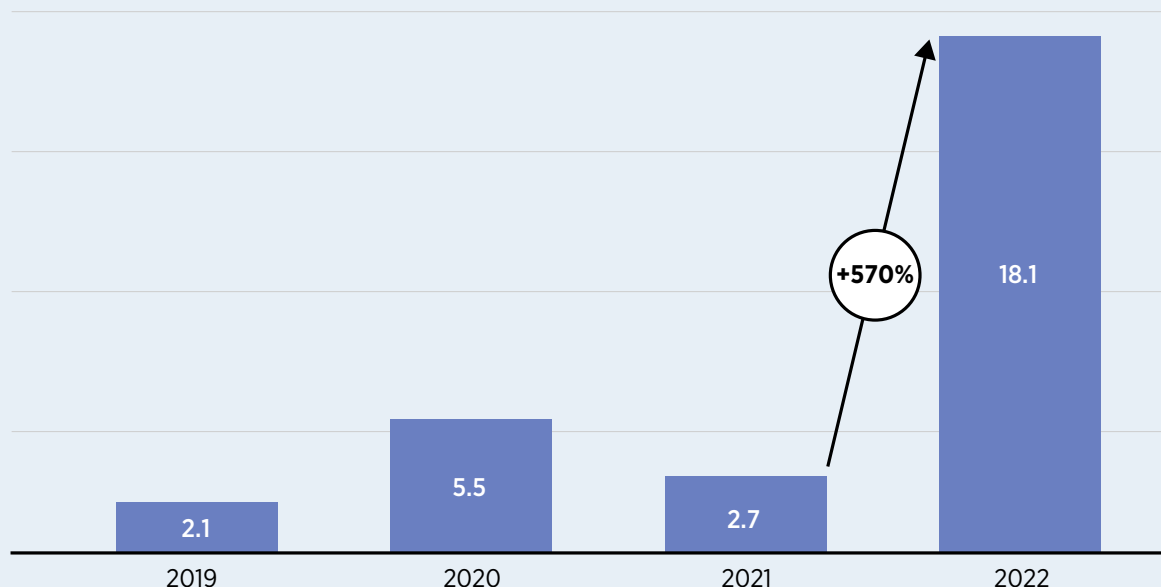
Figure 4 Top 7 sources of FDI into ASEAN, 2021-2023 (in USD billion)



Source: (ASEAN Stats, n.d.).
Notes: ASEAN = Association of Southeast Asian Nations; EU27 = European Union, 27 countries; FDI = foreign direct investment.

Electric vehicles (EVs) are among the top targets of investment in the region. International investment in ASEAN's EV sector reached USD 18 billion in 2022. This was a six-fold increase from the previous year (Figure 5). EV production, which received fluctuating investments between 2019 and 2021, saw an FDI spike. While member states differ in their specific policy commitments to advancing the EV industry, these trends indicate strong regional support overall.

Figure 5 International investment in ASEAN EV-related sectors, 2019-2022 (in USD billion)



Source: (ASEAN Secretariat and UNCTAD, 2024).

Notes: The figure covers mostly mining of critical minerals (nickel and cobalt), battery production and EV manufacturing. ASEAN = Association of Southeast Asian Nations; EV = electric vehicle.

Many ASEAN countries encourage EV adoption through purchase incentives, subsidies, and tax cuts and exemptions. For instance, in 2021, Cambodia cut its import duty on EVs from 30% to 10%, while Lao PDR cut annual road taxes by 30% for EVs against internal combustion engine vehicles. Myanmar exempts battery EVs from various taxes, while Viet Nam has waived registration fees for battery EVs for the first three years and offers a 50% reduction for the subsequent two years. To attract investment in the EV supply chain, countries like Indonesia are lowering electricity tariffs for charging stations and focusing on high-value nickel processing. Thailand has expanded investment incentives and streamlined project approvals, while Malaysia is increasing support for EV charging stations. Singapore employs tax incentives and regulatory frameworks to encourage investment in the EV ecosystem. Meanwhile, Cambodia and Lao PDR are at early stages of EV adoption and are actively promoting private investments in charging infrastructure.

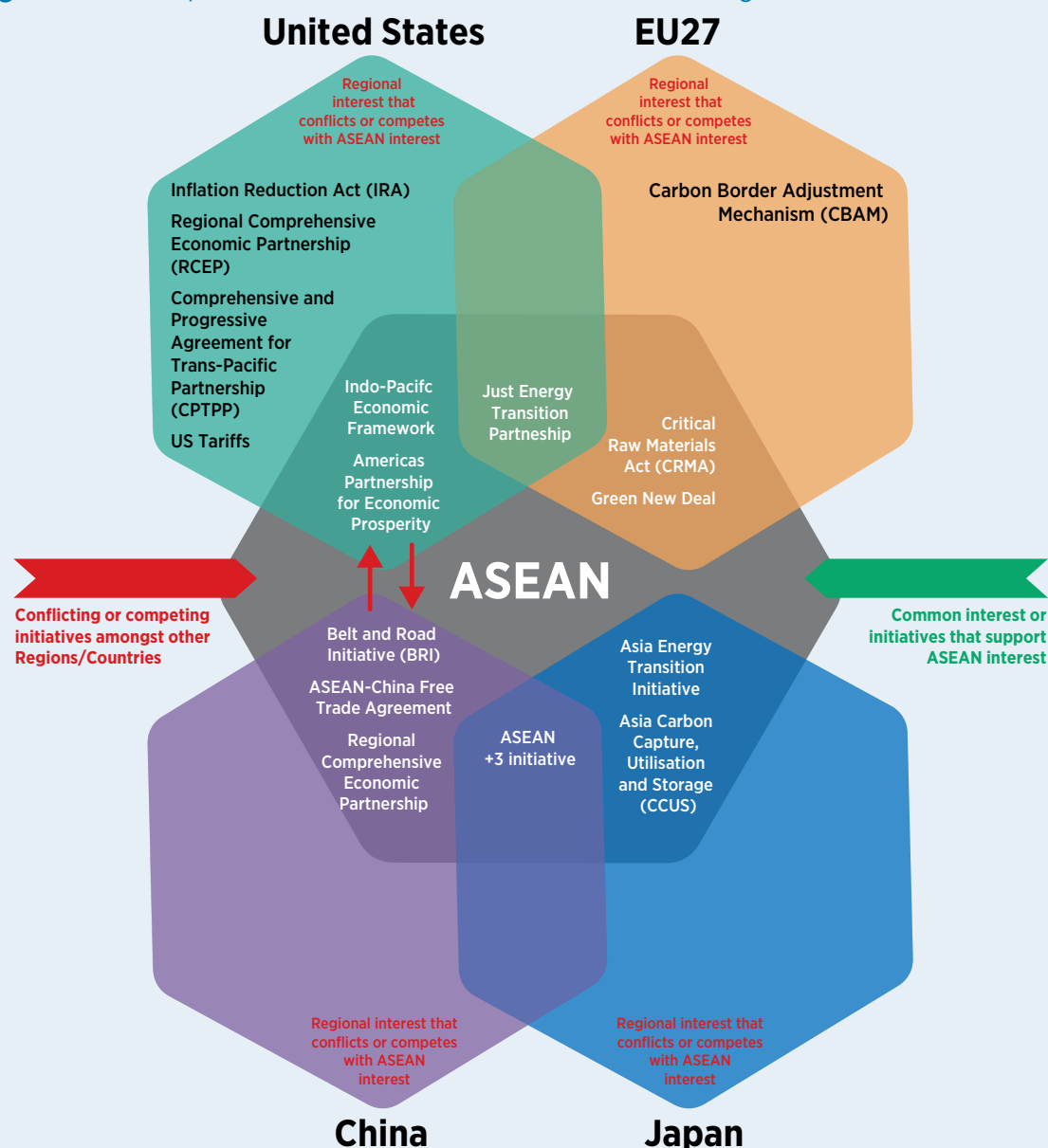
Public investment and expenditure are less front-loaded than in the brief's earlier edition, but follow a steadier trajectory now. They are 1.0% higher yearly on average under the 1.5°C Scenario than under the PES (Figure 3). This indicates ASEAN's shift of focus towards greater balance and longer-term fiscal planning, as well as on sustaining momentum beyond the initial cycles of capital deployment. Annual public investment and expenditure are expected to be roughly 1.0% higher on average throughout the transition period under the 1.5°C Scenario than under the PES, mainly driven by transition-related investments and government social spending.

Consistent with previous results, the analysis shows trade playing a positive role in the economy. Southeast Asia could become a net energy importer, given that rapid energy demand growth in the region is expected to outstrip domestic supply and trigger greater fossil fuel imports through to 2030 (Samanta and Tan, 2019). Under the 1.5°C Scenario, as ASEAN cuts fossil fuel imports, its savings and GDP gains multiply, due to lower energy intensity and greater efficiency, further reducing import dependency. The energy transition also opens opportunities for ASEAN countries and the region as a whole to engage in trade, intra-regionally as well as with other countries and regions. However, the world's shifting geopolitics imply competing arguments for various policy directions; going forward, ASEAN countries must tread carefully (Box 2).

Box 2 Mapping out the geopolitical landscape

As the world pivots towards renewable energy, the member countries of ASEAN are emerging as critical players, both as consumers and producers of green power. ASEAN is strategically positioned at a crucial trade crossroads, with the Strait of Malacca connecting the Indian Ocean and Pacific Ocean. This strait is the shortest maritime route between major oil producers and key Asian markets, including Japan, the Republic of Korea and China. Yet, as trade patterns shift and decarbonisation advances, these long-standing energy dependencies are being reshaped. As a result, and as investments in renewable energy and local manufacturing of transition-related technologies (electric vehicles, batteries) accelerate, control over strategic chokepoints (such as the Strait of Malacca) may become more about influence over emerging technologies.

Figure 6 Examples of initiatives established in the ASEAN region



Notes: The figure does not include intra-ASEAN initiatives/economic frameworks. The Asia Energy Transition Initiative is part of the wider Asia Zero Emission Community (AZEC), a co-operation platform launched by Japan to accelerate Asia's energy transition and decarbonisation. According to the Leaders' Joint Statement Action Plan for the Next Decade (11 October 2024), AZEC collaborates closely with Asian countries through various initiatives, including the Asia Energy Transition Initiative, the Cleaner Energy Future Initiative for ASEAN, the Asia GX Consortium, the Strategic Program for ASEAN Climate and Environment, the ASEAN-Japan Transport Partnership, the ASEAN-Japan Smart Cities Network High Level Meeting and the ASEAN-Japan MIDORI Cooperation Plan. This integrated approach highlights AZEC's role as an umbrella platform for collaboration among these key energy transition efforts. ASEAN = Association of Southeast Asian Nations; EU27 = European Union.

Within this shifting landscape, ASEAN nations must navigate the balance of power between established energy consumers and prosumers like China, the United States and the European Union (EU27) as they compete to dominate the renewable sector and secure their energy futures. Figure 6 highlights some of the initiatives that these countries/regions have established in ASEAN, specifically, (1) initiatives that are directly supporting or collaborating with ASEAN (overlaps with ASEAN in the figure); (2) initiatives that are competing or in conflict with ASEAN's interests (non-overlapping part of the circle); (3) multi-regional collaboration (with multiple overlaps in the figure) and (4) cross-regional conflicting/competing initiatives, that is, initiatives of one country/region conflicting with the interest of another country/region (shown with red arrows).

China's Belt and Road Initiative, combined with its ambitious domestic investments in renewables, has expanded its geopolitical influence both regionally and globally. China has heavily invested in ASEAN solar photovoltaic (PV) manufacturing capacity to circumvent US tariffs on Chinese-made PV products; however, during 2025 and beyond, with tariffs rising, ASEAN-based PV suppliers (most of which are Chinese owned) are likely to come under mounting pressure. Meanwhile, the EU27 and the United States are advancing their own energy and trade strategies. They are pushing to fortify energy security and improve clean technology, while also seeking to strengthen their presence and partnerships in Southeast Asia through infrastructure investment, supply chain partnerships, and diplomatic engagement. The region is significantly engaged in the global market of metals and minerals supply chain. This expansion reflects ASEAN's strategic diversification of trade partnerships beyond Asia, notably with European markets, with an evolving role in the global supply chain of critical minerals.

Within this supply chain competition, ASEAN countries have opportunities and also face challenges. The race to secure access to critical raw materials, essential for renewable technologies, presents new dimensions of economic leverage and strategic partnerships but also risks of dependency and conflict. ASEAN's role is crucial in this evolving landscape; it could become a hub for renewable energy development but also the centre of geopolitical rivalries. The outcome will depend on how ASEAN nations manage their resources, establish partnerships and leverage their position in the new energy order.

After exploring some of the intricate dynamics and the strategic interests of the region's key geopolitical players, it becomes clear that ASEAN countries must balance two tasks: convincing major powers of the importance of the region's strategic autonomy, and navigating intra-regional competition. A key approach is to embrace a broad range of international investment partners, to avoid over-reliance on any player. A diversified foreign direct investment portfolio not only reflects global confidence in the region's stability and growth potential but also serves as a crucial driver for economic development, technology transfer, and job creation.

The consumption of manufactured fuels in road transport, and solid fuels and oil for heating, is expected to reduce substantially due to the increased use of biofuels. Improvements in net fuel trade alone are worth an estimated USD 123.2 billion by 2050. A significant portion of these gains, about one-third, is associated with Indonesia's reduced dependence on imports, while the rest is divided among the other ASEAN economies. As in earlier analysis, the effects of non-fuel trade are moderately negative, because conventional motor vehicles are exported less and advanced vehicles are imported more (due to the supply-demand mismatch for advanced vehicles among ASEAN member states). Collectively, these investment and trade patterns indicate a need to strategically co-ordinate policies and plan infrastructure to optimise the economic benefits of ASEAN's energy transition.

Induced and indirect effects (including aggregate prices and lump-sum payments, and others⁹) have a negative but minor impact on the ASEAN economy over the transition period.¹⁰ This is mainly due to consumer expenditure. In the first two decades, household consumption remains under financial strain due to heightened prices, given carbon taxes and an energy sector that is still fossil-fuel based. The negative effect wears off in the last decade, due to the delayed effect of large lump-sum payments in earlier years, income tax and carbon tax cuts, and increased inflows from global collaboration on the energy transition. Over the transition period, the regional power inter-connection reduces the negative impact of the induced component – aggregate prices (which reflect the domestic response to changes in carbon prices, technology costs, power sector capacity, fossil fuel subsidies and investment expenditure) – on the GDP difference. Carbon prices and the deployment of high-cost renewable technologies under the 1.5°C Scenario drive up energy prices.

⁹ Others include the changes in consumer expenditure (due to income tax rate responses, indirect or induced effects).

¹⁰ A result consistent with the previous report (IRENA, 2023).

Revenue recycling – one of the key policy assumptions of the analysis – leads to lump-sum payments being made directly to lower-quintile households in the 1.5°C Scenario, when the government accumulates excess tax revenues after paying for transition-related investments and other policy costs. By dealing with domestic distribution issues (*i.e.* providing support to the lower-quintile population), revenue recycling thus supports the GDP difference throughout the transition period. The positive effect peaks in the second decade and slightly wears off in the last decade as carbon tax receipts fall in line with emissions. Higher carbon taxes under the 1.5°C Scenario could be a lever to increase the fiscal space for lump-sum payments and their socio-economic benefits. Those additional revenues could help enable additional investments in a just transition.

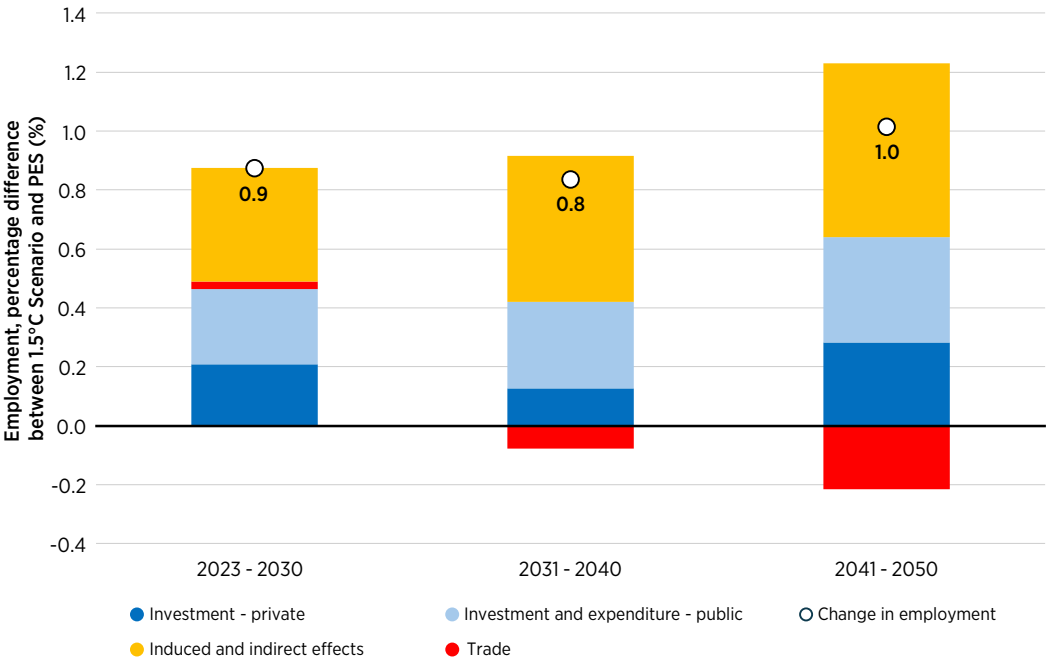
2.2 EMPLOYMENT

Economy-wide employment

The energy transition under the 1.5°C Scenario still generates net positive employment impacts for ASEAN (Figure 7). This updated assessment also shows economy-wide employment gains more equitably distributed across the transition period, supported by more evenly spread contributions from key macroeconomic drivers, especially investments and induced and indirect effects, with a minor impact from trade.

In all three decades of the transition, economy-wide employment is expected to be consistently higher under the 1.5°C Scenario than the PES. The employment difference between scenarios is 0.9% in the first decade (*i.e.* 2023-2030) and 0.8% in the second decade (*i.e.* 2031-2040); it then peaks, at 1.0%, in 2041-2050 (Figure 7). In 2050, the employment difference translates into over 3.5 million additional jobs. The analysis shows that greater regional power inter-connection and more inclusive investment can sustain the upward trend in job creation to the middle of the century.

Figure 7 Economy-wide employment in ASEAN region: Percentage differences between the 1.5°C Scenario and the PES, by driver, 2023-2050



Notes: ASEAN = Association of Southeast Asian Nations; PES = Planned Energy Scenario.

The positive impact of **induced and indirect effects** on the employment difference is due to increased consumer spending, increased wages and a shift in consumption patterns across the transition's decades. Constrained labour supply in the region may positively affect wages – driving them upwards – and drive companies to expand workforces in line with demand. Increased household consumption (led by investment stimulus and lump-sum transfers; see section 2.1) continues to drive employment growth. Under the 1.5°C Scenario, the shift of consumer spending away from fuels to other services, including hospitality, education and personal care, positively affects the economy-wide employment difference. This expenditure reallocation boosts job creation, since labour-intensive activities, required progressively less in declining fossil-fuel-based sectors, gain more from the rising demand. The renewable energy manufacturing sector could also contribute to job growth, as countries scale up domestic production of renewable energy technologies to meet regional and global demand. In ASEAN, industrial policies could position member states as competitive manufacturing hubs for solar PV, battery and EV components.

While **trade** has a positive role to play in the GDP difference, it has a more minor and slightly negative influence on the employment difference between scenarios. This is due to an adjustment in some industries, which are affected by higher imports of advanced technology goods due to increased consumer expenditure (as discussed in the trade patterns and GDP drivers outlined in section 2.1).

Public and private investments are key employment drivers, especially in infrastructure, clean energy programmes and service sectors. The positive effect of these drivers becomes increasingly significant throughout the transition as fiscal policies and international financing under global partnerships continue to stimulate employment. Regional power sector inter-connection and more inclusive investment help offset the loss of investment in fossil fuels. Their benefit grows slowly in influence throughout the transition by way of a steady accrual of capital and a rising presence of domestic and regional players in clean energy value chains – in particular, high in the manufacturing value chain of critical materials as well as EV and battery production (Box 3). The ASEAN region holds world-class reserves of several key minerals, such as nickel, tin, rare earth elements, copper and bauxite, many of which remain largely unexplored for commercial purposes. Meanwhile, member states are key producers and refiners of many essential metals and minerals required for the energy and digital revolutions. This gives ASEAN countries a central position in global supply chains as vital domestic and regional manufacturing hubs for critical metals and minerals.

Box 3 Critical materials and development goals

The resource abundance of the Association of Southeast Asian Nations (ASEAN) positions it at the heart of the global energy landscape. But even as member states have access to energy resources, that is no longer the sole challenge; they must consider renewable energy market developments in terms of technologies and research, basing future energy strategies on the ability to convert energy resources into usable energy at a competitive cost. The energy transition could translate into first and foremost a technological revolution where research and development policies are critical to fostering innovation, with intellectual property rights shaping energy capacity (Crikemans, 2018).

Nevertheless, the surge in demand for critical materials raises important questions about the potential emergence of a resource curse. It is essential to consider whether nations rich in critical minerals will truly benefit from increased market demand or whether they will experience a modern iteration of the “Dutch Disease”. Historically, the resource curse has been associated with oil, natural gas and traditional metals, but the energy transition has shifted focus to previously underutilised resources (Hache *et al.*, 2023). This phenomenon is particularly pertinent for developing countries, which are often more susceptible to over-reliance on a single economic sector and face structural challenges within their political, economic and environmental frameworks. For instance, nickel's new status as a critical transition mineral has notably altered development agendas in Indonesia (IRENA, 2023e), which held

roughly 45% of the world's nickel reserves in 2024 (USGS, 2025). While the rapid expansion of the nickel industry in Indonesia was cast as a national success story due its economic benefit, it has also resulted in the creation of new extractive enclaves marked by limited distribution of benefits, strong foreign and politically connected capital influence, and significant environmental and social externalities, including deforestation and disruption to local communities (Warburton, 2024).

Building resilience and competitiveness in today's globalised and digitally driven world require strong industrial policies. Having a comprehensive grasp of the intricate relationship between industrial growth, sustainability and technological advancement is of utmost importance, especially in the current global transition towards renewable energy. The industrial policies implemented in ASEAN countries strive to foster economic growth by establishing a favourable atmosphere for innovation, investment and technological progress, but these policies must remain resilient and flexible amid shifting global dynamics, such as changes in trade, technology and geopolitics. A more resilient ASEAN framework requires economic systems that can effectively endure and adjust to both internal and external disruptions. This will contribute to the long-term and balanced progress of all member states.

ASEAN must integrate its regional value chains into global value chains and boost productivity through innovation and skill development. These factors have become critical determinants of the region's competitiveness. ASEAN nations must implement strategies that capitalise on their unique strengths, foster co-operation among member countries, and simplify trade and investment procedures. The global transition to renewable energy brings numerous challenges and opportunities for ASEAN: sustainable practices necessitate substantial infrastructural, technological and regulatory adjustments.

As ASEAN countries navigate their position within the critical minerals markets, innovation plays a vital role in ensuring they remain available, affordable and sustainable. Investing in advanced extraction methods, recycling technologies and efficient supply chain management can help ASEAN secure a stable supply of critical minerals while minimising environmental impacts (Table 2). Collaboration among governments, industry stakeholders and financial institutions is essential to accelerate innovation in this sector. By advancing technology and fostering partnerships, ASEAN can strengthen its competitive position in the global critical minerals market, supporting its clean energy goals and economic growth.

Table 2 National strategies for strengthening mineral sector development and value addition in the Association of Southeast Asian Nations

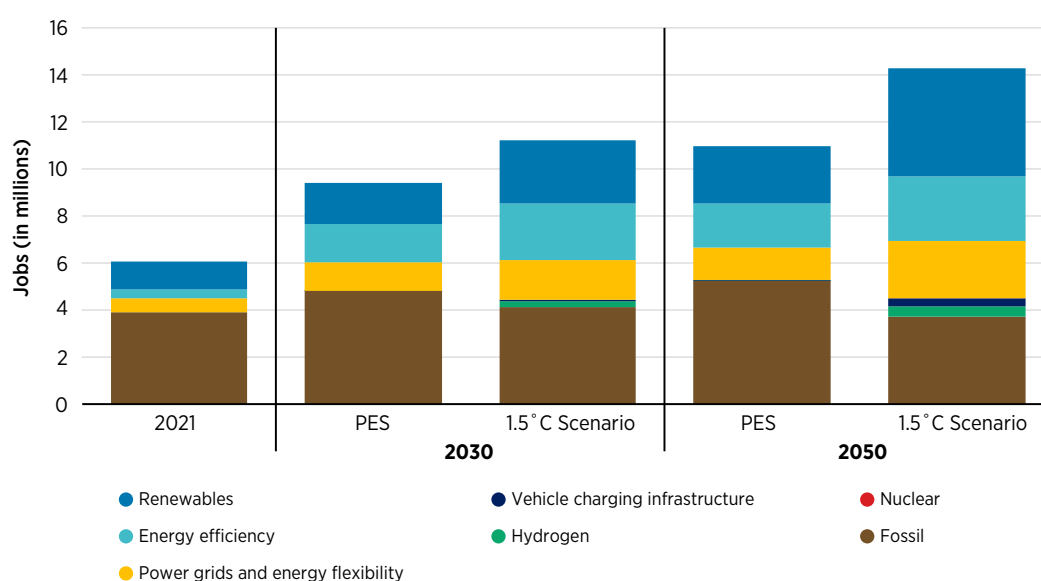
COUNTRY	STRATEGY
Philippines	Plans to expand the extractives and refining sectors to increase domestic value addition and boost manufacturing capabilities across multiple sectors.
Malaysia	Launched the National Mineral Industry Transformation Plan 2021-2030, emphasising downstream value addition, technology and innovation.
Indonesia	Implemented robust policies for adding value to mineral production, including a ban on raw mineral exports and a domestic processing requirement, and supports vertical integration into advanced value chains.
Viet Nam	The Mineral Resources Strategy to 2020, with a vision towards 2030, focusses on maximising the potential of the mineral sector and promoting domestic value addition.
Cambodia	The National Policy on Mineral Resources 2018-2028 highlights potential for mineral exploration and development.
Lao PDR	The National Green Growth Strategy 2030 identifies the mining and mineral sectors as key areas for economic and social development.

These findings highlight a need for long-term policy frameworks incorporating just transition mechanisms, labour market strategies and regional co-operation to ensure the energy transition not only helps ASEAN mitigate climate risks but also promote region-wide inclusive growth and employment.

Energy sector jobs

This 2025 update provides a breakdown and an optimistic projection of employment in the ASEAN energy sector under the 1.5°C Scenario. The newly updated analysis paints a more consistent picture than the previous edition, which foresaw modest job growth and fossil fuel employment waning more quickly than clean energy job growth could make up for. In this update, total energy sector employment under the 1.5°C Scenario is expected to amount to about 14.3 million jobs in 2050, well more than the 11.0 million under the PES and close to 2.5 times the 6.1 million jobs of 2021 (Figure 8).

Figure 8 Overview of energy sector jobs in ASEAN under the PES and the 1.5°C Scenario, by sector, 2021-2050



Notes: ASEAN = Association of Southeast Asian Nations; PES = Planned Energy Scenario.

This growth runs parallel to an important change in the energy workforce. Fossil fuel jobs remain substantial in the near term – 4.1 million by 2030 – but fall to 3.7 million by 2050 under the 1.5°C Scenario. Their reduction reflects declining, yet ongoing, investments in coal, oil and gas, alongside the gradual phasing out of fossil fuel infrastructure. By contrast, jobs in renewable energy are almost four times higher in 2050 under the 1.5°C Scenario (4.6 million, up from 1.2 million in 2021) than the PES (approximately 2.4 million).

Energy efficiency stands out as a major job creator, with jobs growing from 0.4 million in 2021 to 2.8 million in 2050 under the 1.5°C Scenario. This is due to deep building retrofits, electrification of industry and transport, and massive efficiency gains across end-use sectors enabled by regional power sector inter-connection and more inclusive investment. Employment related to power grids and energy system flexibility also grows, though at a slower pace, from 0.6 million in 2021 to 2.4 million in 2050 under the 1.5°C Scenario. This is almost double the 1.3 million reported in the first edition of the Socio-economic Footprint of the Energy Transition: Southeast Asia (IRENA, 2023a), which reflected assumptions in line with the 2021 edition of the World Energy Transitions Outlook (IRENA, 2021a). The positive trend indicates increasing spending on inter-connection infrastructure, digitalisation and the storage required to accommodate a renewables-based power system.

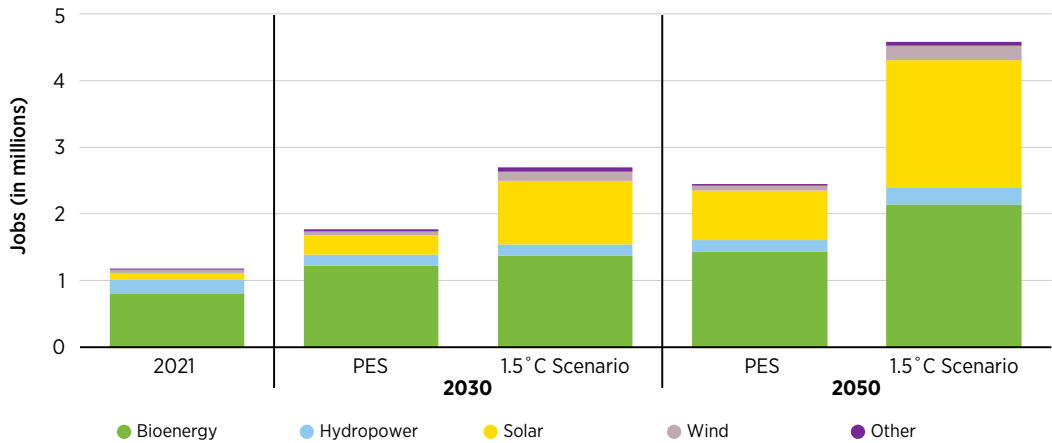
There are also new jobs in emerging sectors. While hydrogen sectors have negligible jobs today, demand for low-carbon fuels is expected to increase employment to more than 450 000 jobs by 2050. Charging infrastructure for cars, crucial for ASEAN’s switch to electric mobility, could create around 330 000 jobs by 2050. Together, these changes suggest a structural transformation in the ASEAN energy labour market towards a more sustainable, decentralised and skilled workforce.

While the transition is expected to generate more employment across renewable energy, energy efficiency and the transition-related manufacturing sectors by 2050, fossil fuels, which still supply a majority of the region’s energy demand, absorb a significant portion of the workforce in the near term. This structural dependence creates a skill mismatch: many workers currently employed in conventional energy sectors may not possess the technical competencies required in emerging green industries. Targeted re-skilling and upskilling programmes will be needed, as well as just transition policies that help displaced workers move into quality jobs in the low-carbon economy and also equip new entrants to meet the growing labour demand of the energy transition. Regional co-operation on training standards, vocational education and labour mobility could help harmonise workforce development across member states.

Renewable energy jobs

Renewable energy will likely be the biggest source of energy sector jobs in ASEAN in the 1.5°C Scenario; total renewable energy employment will amount to 4.6 million jobs by 2050; this is almost double the renewable energy jobs under the PES and almost four times the 1.2 million jobs in 2021 (Figure 9). The increase is due to more widespread use of all types of renewables and increased local manufacturing, installation and maintenance.

Figure 9 Overview of renewable energy jobs in ASEAN under the PES and the 1.5°C Scenario, 2021-2050



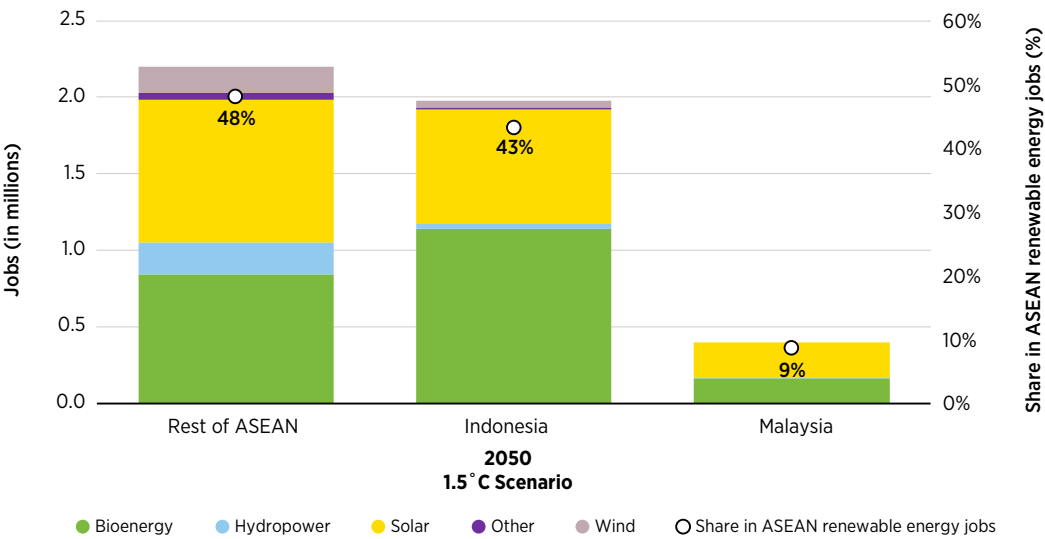
Notes: ASEAN = Association of Southeast Asian Nations; PES = Planned Energy Scenario.

In the renewables sector, bioenergy continues to be the largest employer, despite declining labour intensity; this is because the sector has a high workforce requirement and rural value chains are extensive. Employment in bioenergy grows from over 812 000 jobs in 2021 to more than 2.1 million jobs in 2050 under the 1.5°C Scenario. This strong growth reflects bioenergy’s role in ASEAN as an essential driver of both clean energy and rural development. Jobs in solar also increase over the period, from fewer than 100 000 jobs in 2021 to more than 1.9 million jobs by 2050 under the 1.5°C Scenario. The ongoing worldwide roll-out of rooftop systems combined with utility-scale installations and capacity expansion of value chains in countries that include Viet Nam, Malaysia and Thailand, drives this expansion.

Wind energy jobs also grow steadily, from just below 50 000 jobs in 2021 to more than 220 000 by 2050. While this is modest compared with solar and bioenergy, it nevertheless indicates incremental expansion in on-shore and off-shore wind capacity in ASEAN markets. Hydropower jobs, which remain relatively consistent, rise slightly, from around 203 000 in 2021 to 253 000 in 2050. The deployment of small hydropower and efficiency improvements in existing facilities mainly drives this growth. Geothermal, marine and other emerging renewables continue to represent a small share but are expected to generate more than 50 000 jobs by 2050, reflecting specialised market developments in regions with specific resource endowments. In summary, the renewable energy workforce in ASEAN gradually becomes more heterogeneous and technologically advanced, calling for co-ordinated investment in vocational training, certification programmes and industry-academia collaboration.

Figure 10 shows a breakdown of the region’s energy sector jobs in the year 2050 under the 1.5°C Scenario. Indonesia leads, contributing 43% of the region’s renewable energy jobs. Its dominance is mainly driven by bioenergy, at more than 1.1 million jobs (or more than 57% of the country’s renewable jobs) and solar (*i.e.* PV and concentrated solar power), at around 746 000 jobs (or 38%). Malaysia contributes 9% of the region’s renewable jobs, largely from solar, at 224 000, and bioenergy, at 162 000. The other ASEAN countries contribute the remaining 48% of the region’s renewable jobs. By 2050, solar stands at 936 000 jobs, bioenergy at 843 000 jobs, hydro at 208 000 jobs and wind at 175 000 jobs.

Figure 10 Renewable energy jobs in ASEAN region under the 1.5°C Scenario, by country, 2050



Notes: “Other” includes geothermal and tidal/wave. ASEAN = Association of Southeast Asian Nations.

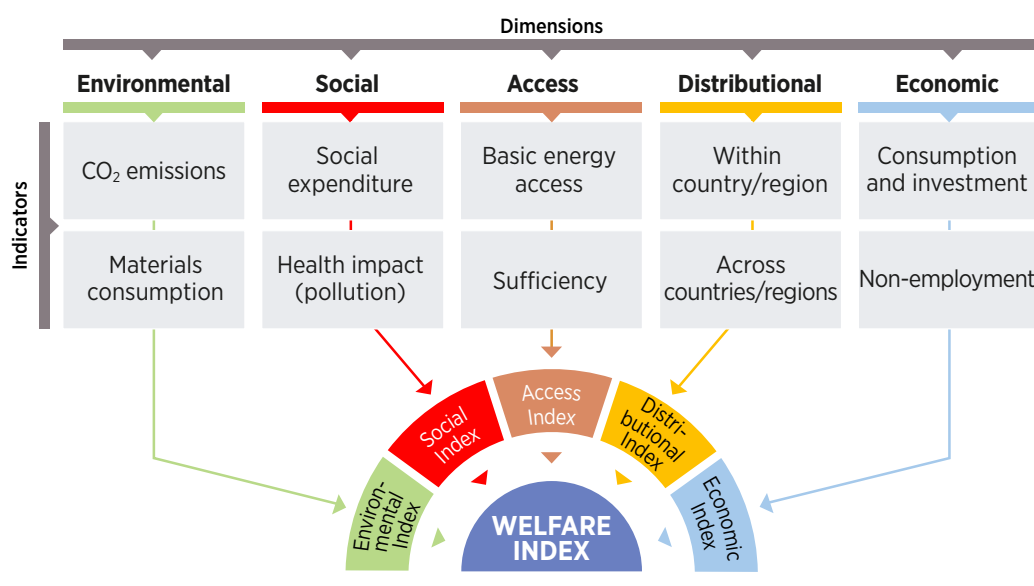
Compared with the previous edition, this updated analysis highlights that the region has significant employment potential under the 1.5°C Scenario, to be unlocked by appropriate policies. One such measure would be the regional inter-connection that supports in building a more dynamic employment landscape. Region-wide inclusive job creation and economic transformation would be driven by ambitious climate action combined with regional power inter-connection consistent with the 1.5°C goal.

2.3 WELFARE

GDP is the standard measure of economic output. The concerns of citizens, however, go beyond GDP, which does not include or consider factors that are not priced into the market, such as human health, jobs and environmental quality. And while climate change will likely negatively impact future GDP, it also will have significant social, nature and economic impacts that no measure of GDP captures. Conventional indicators such as GDP are thus incomplete and potentially misleading, as they do not consider future constraints of natural resources and climate. To consider key aspects of societal well-being, IRENA has developed and refined its Energy Transition Welfare Index (ETWI) (IRENA, 2016, 2019a, 2019c, 2020, 2021a, 2022b, 2023d, 2024) for an extended impact analyses.

The methodological framework of the ETWI allows direct comparison between scenarios, revealing potential challenges (and opportunities) for policy makers. The index measures ten indicators across five dimensions (economic,¹¹ social,¹² environmental,¹³ distributional¹⁴ and access¹⁵ [Figure 11; IRENA, 2021a]) to illustrate how targeted policies can improve socio-economic outcomes. Once indicators are normalised, they are aggregated through an equally weighted geometric mean to generate the dimension indices, and in turn aggregated to the overall welfare index using the logarithmic shares. Similar methodological frameworks are used by other international and multilateral organisations for their respective indices, for example, the Competitive Industrial Performance of the United Nations Industrial Development Organization (UNIDO) and the Africa Industrialisation Index of the African Development Bank (AfDB). The indices of UNIDO and AfDB measure industrial performance and competitiveness based on a set of 8 and 19 indicators, respectively (AfDB *et al.*, 2022; UNIDO, 2013).

Figure 11 Structure of IRENA's Energy Transition Welfare Index



Source: (IRENA, 2021a).

Notes: CO₂ = carbon dioxide; IRENA = International Renewable Energy Agency.

¹¹ The economic dimension is composed of two indicators: (1) per capita consumption and investment; and (2) the non-employment rate, which is the share of the working age population that is neither employed nor under education.

¹² The social dimension is composed of two indicators: (1) social expenditure, expressed as per capita public expenditure; and (2) health impacts of pollution, expressed as capita health damages due to energy-related air pollution.

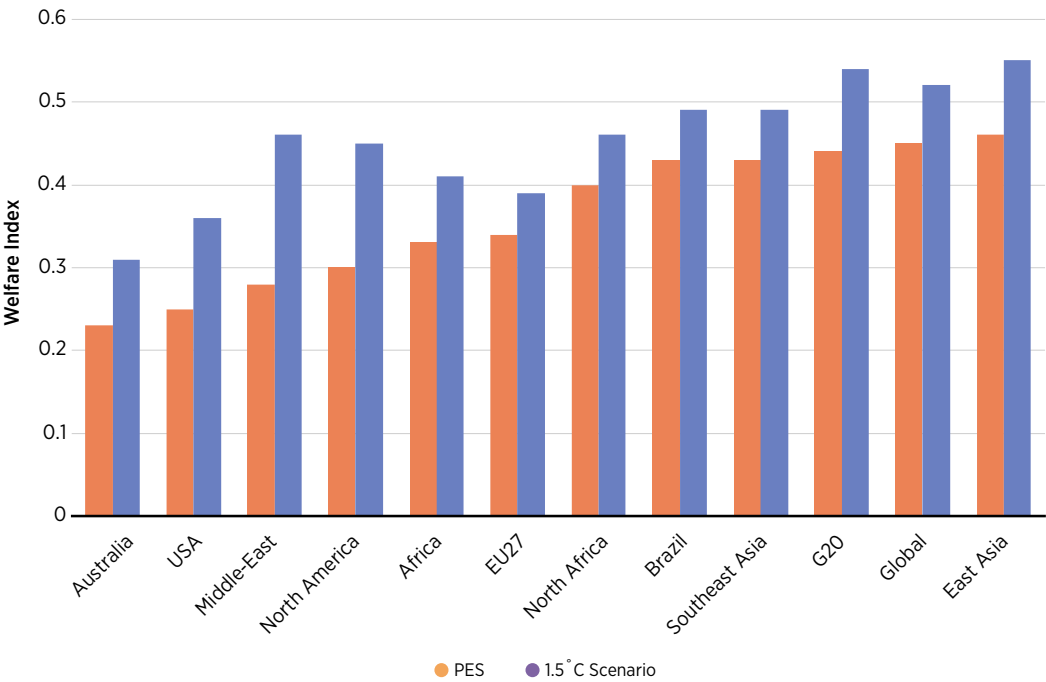
¹³ The environmental dimension consists of two indicators: (1) cumulative CO₂ emissions; and (2) per capita materials consumption, which is expressed in terms of domestic materials consumption and includes metals, non-metallic minerals and biomass (wood, food) but excludes fossil fuels.

¹⁴ The distributional dimension measures income and wealth inequality within and across ASEAN countries.

¹⁵ The access dimension is informed by (1) the rate of access to basic energy and (2) progress in energy sufficiency level (assumed at 20 kilowatt hours/capita/day) in line with the literature (Millward-Hopkins *et al.*, 2020).

The five dimensions of the ETWI are evaluated on a scale from 0 (low performance) to 1 (high performance). Figure 12 presents the average ETWI values for the PES and the 1.5°C Scenario in selected regions throughout the transition period (2023-2050). The highest-performing cases have an ETWI value of 0.5, at most, indicating non-achievement of substantial socio-economic goals and considerable room for improvement. The Southeast Asian energy transition is not just boosting economic development and employment, but also driving the regional ETWI up across the period, indicating significant improvement in quality of life in the region. This improvement reflects gains from the early deployment of renewable energy, electrification and energy efficiency and greater investment in public infrastructure and social spending under the 1.5°C Scenario.

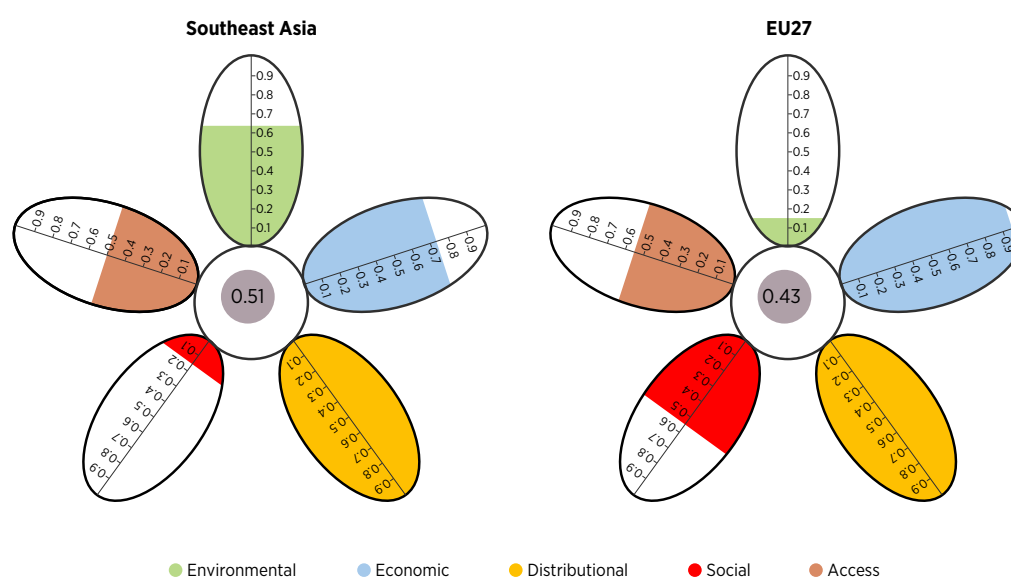
Figure 12 IRENA ETWI under the PES and the 1.5°C Scenario for selected regions, 2023-2050



Notes: The IRENA ETWI is on a scale from 0 (low performance) to 1 (high performance) and represents the absolute value of the overall welfare index. G20 = Group of Twenty; ETWI = Energy Transition Welfare Index; EU = European Union; IRENA = International Renewable Energy Agency; PES = Planned Energy Scenario.

But although the ETWI allows for clear comparisons, it explains neither the results drivers nor which policy instruments enable specific improvements. IRENA therefore provides indices for each dimension to shed light on the drivers. Figure 13 shows the five dimensions for Southeast Asia and EU27 in 2050 under the 1.5°C Scenario.

Figure 13 Overall ETWI and its dimensional indices under the 1.5°C Scenario in 2050 for EU27 and Southeast Asia



Notes: The five petals are on a scale from 0 (low performance) to 1 (high performance) and represent the absolute values of the five dimensions of the welfare index. The number in the centre is also on a scale from 0 to 1 and represents the absolute value of the overall welfare index. ETWI = Energy Transition Welfare Index; EU = European Union.

Figure 13 shows that the regions could have very different dimensional profiles. EU27 scores higher in the economic, social and distributional dimensions, while Southeast Asia performs significantly better in the environmental dimension, due to much-reduced CO₂ emissions. It also suggests that Southeast Asia could improve significantly in the social dimension, although potential for additional improvement in the economic, environmental and distributional dimensions is less. While the economic aspect has been largely discussed (in section 2.2), another focus area is the environmental dimension, which is the third-largest driver of welfare improvement under the 1.5°C Scenario. Almost all the welfare benefits of the energy transition result from much-reduced CO₂ emissions, which mitigates the effects of climate change, although material consumption continues to increase under the PES and the 1.5°C Scenario, dragging down the absolute environmental dimension. The increase in material consumption could be due to an expected increase in critical materials production in the region, which, though presenting an adverse environmental impact, is also a sector that Southeast Asia is relying on heavily for its development and clean energy transition (see Box 4 in section 2.2).

This new analysis also highlights the potential role of regional energy inter-connection and lower fossil fuel consumption in improving the trade balance and public health, both key determinants of regional welfare. Regional infrastructure integration facilitates a fair and inclusive energy transition that enables wide sharing of welfare benefits through adequate cross-border access to clean energy.

The modest contributions of the social and distributional dimensions reflect that structural challenges remain embedded, calling for targeted policies to address inequality and social protection.

The welfare gains under the 1.5°C Scenario therefore not only result from economic output, but also represent a more general shift towards healthier environments, greater access to energy and resilient livelihoods. Policy support and regional co-operation can help build up these gains post 2050.

CHAPTER 3

CONCLUSION

ASEAN's energy transition in the 1.5°C Scenario provides an opportunity to achieve inclusive growth by leveraging regional power inter-connection, clean energy investments and structural transformation to support growing GDP and employment. Member countries could support renewable energy deployment, energy efficiency and grid modernisation to boost public investment, drive job creation and raise household consumption. By 2050, ASEAN is expected to create 3.5 million additional jobs and achieve 3.7% higher GDP than under the PES. The jobs growth is driven by renewable energy, notably bioenergy and solar PV. Bioenergy remains the leading renewable due to its reliance on rural labour, while solar jobs grow significantly across the value chain in Malaysia, Viet Nam and Thailand. Both GDP and employment continue to be structurally driven by private and public investment and trade.

ASEAN stands at a crossroads in its transition, and external actors, from Japan's pragmatic energy diplomacy and the United States's selective partnerships to China's infrastructure-based investments and the European Union's regulatory ambitions, are profoundly shaping its strategic choices. The region must navigate simultaneous challenges: accelerating its shift towards renewable-energy-based systems, capitalising on its increasing presence in the global critical mineral market, and balancing these economic opportunities with geopolitical complexities and urgent sustainability imperatives.

This updated brief therefore highlights key priorities for ASEAN to maximise its energy transition benefits. It provides a roadmap to guide policy design and efficiently navigate the transition's complexity while ensuring sustainable and equitable growth, paired with socio-economic advancement, across member states. Policy makers must consider several axes of strategic significance:

- Harmonising renewable energy policies through the development of common standards for grid integration, procurement and investment; this would be crucial for horizontal growth and interoperability across member states.
- Anchoring energy transition policies within just transition frameworks, and also deepening co-operation at the regional level, especially on infrastructure and grid inter-connection. The region could fortify energy security and increase strategic autonomy by leveraging national strategies with added value in mineral sectors, promoting innovation and enabling regional inter-connection.
- Boosting regional energy security through critical minerals development and grid inter-connections while mandating technology transfer and environmentally aligned FDI; these steps promise mutual gains for energy security and efficiency across the region.
- Leveraging renewable energy growth, particularly of solar PV and bioenergy, to maximise socio-economic benefits. PV holds considerable potential for creating jobs in industry and for attracting private investment across ASEAN countries. In parallel, bioenergy could be beneficial for decentralised energy systems, particularly in rural areas. Targeted re-skilling and upskilling initiatives, vocational training programmes, and stronger integration between education systems and industry needs are crucial to leverage the potential of these technologies to contribute socio-economic and overall welfare benefits.

- Facilitating the just transition in fossil-fuel-dependent ASEAN countries – particularly Indonesia, where coal constitutes over 60% of power generation – by scaling up re-skilling programmes, social protection schemes and targeted investments in renewable energy industries as coal is phased out.
- Co-ordinating policies through established ASEAN institutions to prioritise cross-border clean energy projects with transparent FDI rules that align with local priorities. This also would include information sharing and the incentivisation of research and development to ensure regional resilience while preventing dependency on external actors.
- Implementing just transition policies that convert geopolitical challenges into opportunities, and balance external partnerships with domestic priorities.

To ensure equitable benefit sharing, ASEAN must therefore follow a path that balances development goals with sustained resilience.

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ANNEX

COMPARING THE RESULTS OF THE FIRST EDITION (2023) OF THE SOCIO-ECONOMIC FOOTPRINT ASSESSMENT AND THIS (2025) UPDATED ASSESSMENT

This annex compares the results for gross domestic product (GDP) and employment in the Association of Southeast Asian Nations (ASEAN) between the first edition of the *Socio-economic footprint of the energy transition: Southeast Asia* (IRENA, 2023a) and this updated brief (2025).

The first edition (IRENA, 2023a), which reflected assumptions in line with the 2021 edition of the *World Energy Transitions Outlook* (IRENA, 2021a), estimated that annual average GDP and employment growth in ASEAN could be, respectively, 3.4% higher and 1.0% higher between 2021 and 2050 under IRENA's 1.5°C ° Scenario, compared with the Planned Energy Scenario (PES). In contrast to the previous analysis, this updated version, informed by the 2nd edition of the *Renewable Energy Outlook For ASEAN: Towards a Regional Energy Transition* (IRENA *et al.*, 2022), projects slightly more conservative gains, of 2.6% and 0.9%. Both analyses conclude that pursuing an energy transition aligned with the 1.5°C goal can bring economic and employment opportunities in the region.

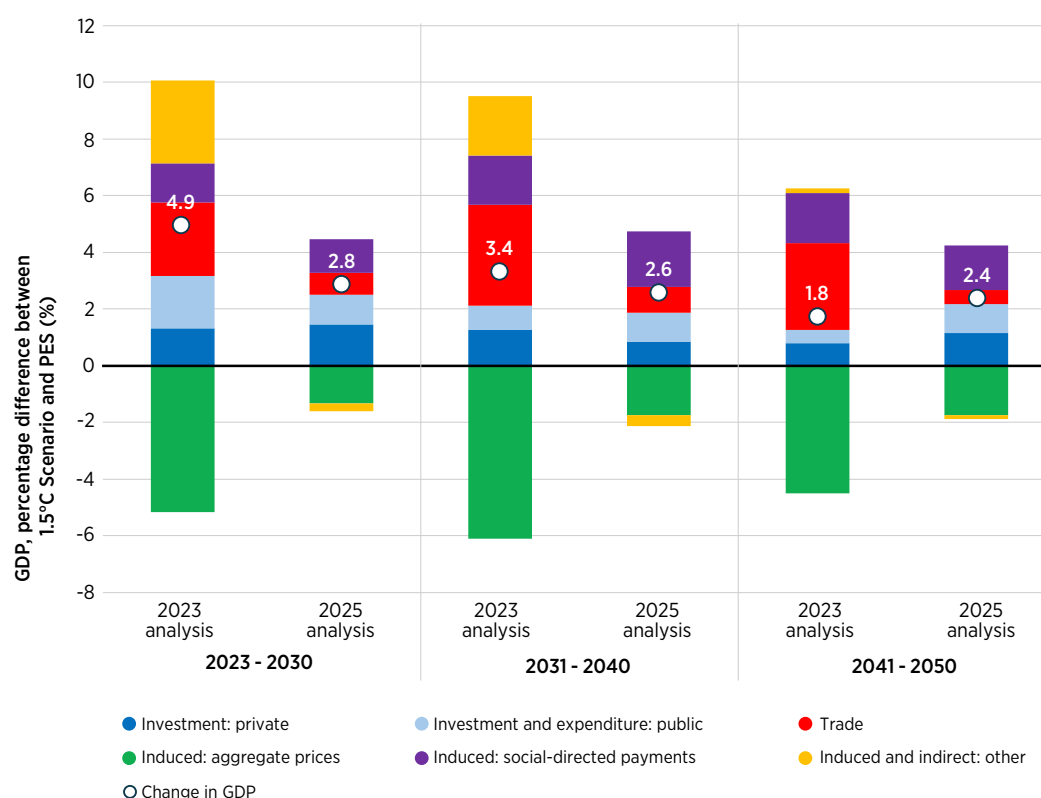
GROSS DOMESTIC PRODUCT

This updated version estimates that ASEAN's GDP would rise by a yearly average of 2.6% between 2023 and 2050 under the 1.5°C Scenario against the PES, highlighting economic benefits. But this growth is slightly below the 3.4% reported in the first edition of the assessment (IRENA, 2023a), which evaluated outcomes between 2021 and 2050. However, in contrast to the previous analysis, where the GDP difference started strong at 4.9% in the first decade (*i.e.* 2023-2030) and slowed towards 1.8% at the end of the 2040s (*i.e.* 2041-2050), the new estimates present a more stable and evenly distributed gain across all three decades.

This shift towards balanced long-term impacts from a pattern of more front-loaded growth results from the inclusion of regional power inter-connection and additional social-directed spending, which make the transition more resilient and inclusive. It also mirrors a maturing policy environment across ASEAN that has amplified focus on sustaining the economic momentum beyond the initial wave of transition-related investments.

Investment and trade remain the main drivers of the GDP difference between the scenarios, while indirect and induced effects play a much smaller role (Figure 14).

Figure 14 GDP in ASEAN region: Percentage differences between the 1.5°C Scenario and the PES, by driver, 2023-2050



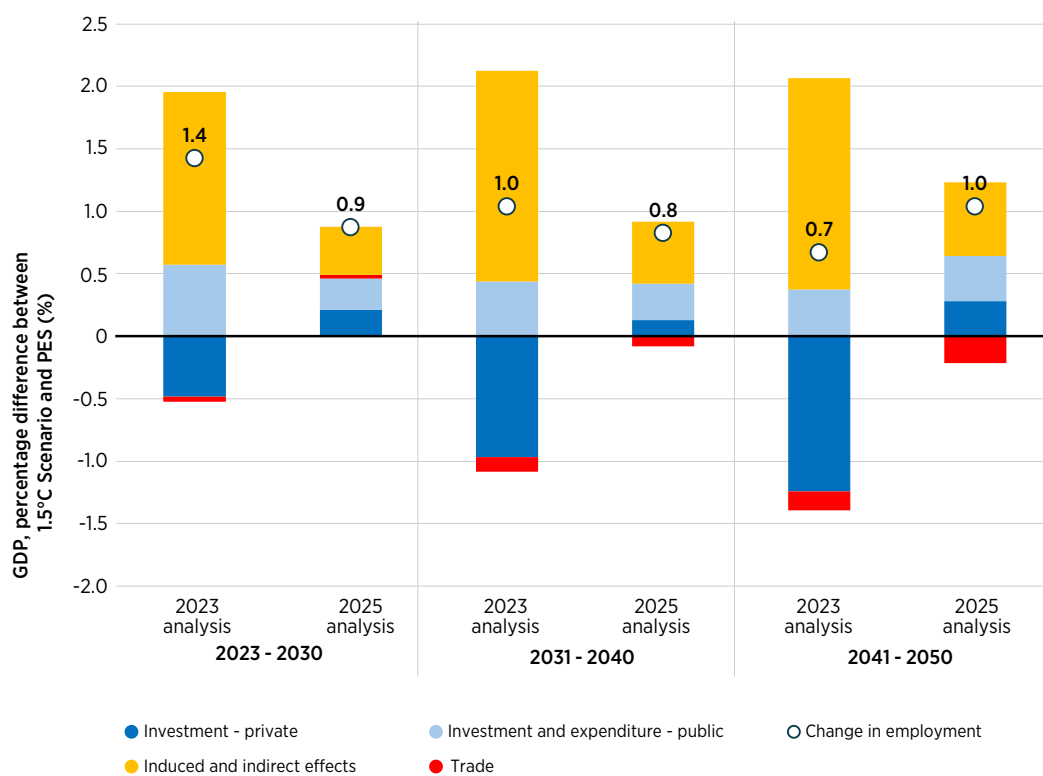
Notes: ASEAN = Association of Southeast Asian Nations; GDP = gross domestic product; PES = Planned Energy Scenario.

ECONOMY-WIDE EMPLOYMENT

The energy transition under the 1.5°C Scenario still results in net positive employment impacts for ASEAN, of 0.9%, compared with 1.0% in the previous edition (Figure 15). Meanwhile, this updated assessment also demonstrates a more balanced distribution of economy-wide employment gains across the transition period, supported by a more evenly spread contribution from key macroeconomic drivers, especially investment, and induced and indirect effects, while trade has a minor impact.

The updated analysis projects consistently higher economy-wide employment in all three decades under the 1.5°C Scenario versus the PES. The employment difference between the scenarios is 0.9% in the first decade (*i.e.* 2023-2030), then 0.8% in the second (*i.e.* 2031-2040) and peaks, at 1.0%, by 2041-2050 (Figure 15). This translates to over 3.3 million additional jobs every year throughout the transition period (*i.e.* 2023-2050). This is a more evenly sustained gain in employment throughout the transition than in the first edition (IRENA, 2023a), which had projected a front-loaded job growth, with the largest differential concentrated in the earlier years (1.4% through to 2030), tapering down to 0.7% in the last decade, 2050. The updated modelling shows that embedding regional power sector inter-connection and more inclusive investment can sustain the upward job creation trend to mid-century. The positive impact of induced and indirect effects on the employment difference is still driven by increased consumer spending, increased wages and a pattern of consumption change across the transition's decades. In this updated analysis, the role of indirect and induced effects becomes increasingly important in the total job creation throughout the transition.

Figure 15 Economy-wide employment in ASEAN, percentage differences between the 1.5°C Scenario and the PES, by driver, 2023-2050



Notes: ASEAN = Association of Southeast Asian Nations; PES = Planned Energy Scenario.

